

WHAT IS CLAIMED IS:

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1. An exhaust gas purifying system comprising:
 a NOx treating catalyst for reducing NOx disposed in an
 exhaust gas passageway of a combustion device, to reduce NOx in
 5 presence of reducing components in exhaust gas; and
 a hydrogen enriching device disposed upstream of said
 NOx treating catalyst with respect to flow of exhaust gas from the
 combustion device and arranged to increase a ratio of hydrogen to
 total reducing components in at least one of combustion gas and
 10 exhaust gas so as to meet relations represented by following
 formulae (1) and (2), when reduction of NOx is carried out by said
 NOx treating catalyst:

$$[H_2 / TR]_d > [H_2 / TR]_u \dots (1)$$

$$[H_2 / TR]_d \geq 0.3 \dots (2)$$
 15 where $[H_2 / TR]_u$ is a ratio between a concentration $[H_2]_u$ of
 hydrogen and a concentration $[TR]_u$ of total reducing components in
 at least one of exhaust gas in the exhaust gas passageway upstream
 of said hydrogen enriching device and combustion gas in a state
 before undergoing the hydrogen ratio increasing by said hydrogen
 20 enriching means; and $[H_2 / TR]_d$ is a ratio between a concentration
 $[H_2]_d$ of hydrogen and a concentration $[TR]_d$ of total reducing
 components in exhaust gas in the exhaust gas passageway upstream
 of the NOx treating catalyst and downstream of said hydrogen
 enriching device.
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2. An exhaust gas purifying system as claimed in Claim 1,
 wherein said hydrogen enriching device is arranged to increase a
 ratio of hydrogen to carbon monoxide in the total reducing
 components in exhaust gas so as to meet a relation represented by
 30 the following formula $[H_2 / CO]_d > 1$ where $[H_2 / CO]_d$ is a ratio
 between a concentration $[H_2]_d$ of hydrogen and a concentration
 $[CO]_d$ of carbon monoxide in the total reducing components in
 exhaust gas in the exhaust gas passageway immediately upstream of

the NOx treating catalyst and downstream of said hydrogen enriching device, when reduction of NOx is carried out by said NOx treating catalyst.

- 5 3. An exhaust gas purifying system as claimed in Claim 1,
wherein said hydrogen enriching device is at least one selected from
the group consisting of a device for producing hydrogen in at least
one of combustion gas and exhaust gas, a device for decreasing the
reducing components other than hydrogen in at least one of
10 combustion gas and exhaust gas, a device for suppressing
consumption of hydrogen in at least one of combustion gas and
exhaust gas, and a device for introducing hydrogen into at least one
of combustion gas and exhaust gas.

- 15 4. An exhaust gas purifying system as claimed in Claim 3,
wherein the device for producing hydrogen in at least one of
combustion gas and exhaust gas includes at least one selected from
the group consisting of a hydrogen producing catalyst containing at
least one noble metal, and a combustion control device for
20 controlling at least one selected from the group consisting of
operating parameters of an internal combustion engine and
combinations of the operating parameters, the operating parameters
including fuel injection timing, spark timing, opening and closing
timings of intake and exhaust valves of the internal combustion
25 engine.

5. An exhaust gas purifying system as claimed in Claim 3,
wherein the device for decreasing the reducing components other
than hydrogen in at least one of combustion gas and exhaust gas
30 includes a CO and HC selective oxidation catalyst containing
zirconium oxide, for selectively oxidize CO and HC.

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6. An exhaust gas purifying system as claimed in Claim 3, wherein the device for suppressing consumption of hydrogen in at least one of combustion gas and exhaust gas is a catalyst containing solid acidic zirconium oxide.

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7. An exhaust gas purifying system as claimed in Claim 3, wherein the device for introducing hydrogen into at least one of combustion gas and exhaust gas is a device for supplying hydrogen-contained gas produced by using hydrocarbon fuel and air, from outside of the exhaust passageway.

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8. An exhaust gas purifying system as claimed in Claim 7, wherein the device for supplying hydrogen-contained gas includes a hydrogen-contained gas producing catalyst for promoting reaction for producing hydrogen-contained gas from the hydrocarbon fuel, and a device for supplying the hydrocarbon fuel and air to the catalyst.

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9. An exhaust gas purifying system as claimed in Claim 8, wherein the hydrogen-contained gas supply device further includes an oxygen concentration sensor disposed upstream of the hydrogen-contained gas producing catalyst so as to detect a concentration of oxygen, and a temperature sensor disposed downstream of the hydrogen-contained gas producing catalyst so as to detect a temperature of the hydrogen-contained gas producing catalyst, wherein amounts of hydrocarbon fuel and air to be supplied to the hydrogen-contained gas producing catalyst are controlled in accordance with the temperature of the hydrogen-contained gas producing catalyst.

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10. An exhaust gas purifying system as claimed in Claim 8, wherein the hydrogen-contained gas supply device includes a device for decreasing the amount of hydrocarbon fuel to be supplied and

increasing the amount of air to be supplied so as to increase a concentration of oxygen, when the temperature of the hydrogen-contained gas producing catalyst is lower than a level.

11. An exhaust gas purifying system as claimed in Claim 7, wherein the hydrogen-contained gas supply device includes a device for producing hydrogen-contained gas by using hydrocarbon fuel and exhaust gas under heat.

12. An exhaust gas purifying system as claimed Claim 7, wherein the hydrogen-contained gas supply device includes a device for temporarily storing hydrogen-contained gas which has been produced, before being supplied to said NOx treating catalyst.

13. An exhaust gas purifying system of a multiple step control type in combination with an internal combustion engine having an exhaust gas passageway,

said engine includes a combustion system having a combustion control device for controlling at least one selected from the group consisting of operating parameters of the engine and combinations of the operating parameters, the operating parameters including fuel injection timing, spark timing, opening and closing timings of intake and exhaust valves of the engine;

said exhaust gas purifying system including

a NOx treating catalyst for reducing NOx disposed in the exhaust gas passageway to reduce NOx in presence of reducing components in exhaust gas, and

a hydrogen enriching device disposed upstream of said NOx treating catalyst with respect to flow of exhaust gas and including at least one selected from the group consisting of a hydrogen producing catalyst containing at least one noble metal, a CO and HC selective oxidation catalyst containing zirconium oxide, a catalyst containing solid acidic zirconium oxide, and a device for

5 supplying hydrogen-contained gas produced by using hydrocarbon
 fuel and air, from outside of the exhaust passageway, said
 hydrogen-contained gas supplying device including at least one of a
 first hydrogen-contained gas supplying device having a
 10 hydrogen-contained gas producing catalyst for promoting reaction
 for producing hydrogen-contained gas from the hydrocarbon fuel,
 and a device for supplying the hydrocarbon fuel and air to the
 catalyst, and a second hydrogen-contained gas supplying device for
 producing hydrogen-contained gas by using hydrocarbon fuel and
 15 exhaust gas under heat,

said hydrogen enriching device being arranged to increase
 a ratio of hydrogen to total reducing components in at least one of
 combustion gas and exhaust gas so as to relations represented by the
 following formulae (1) and (2), when reduction of NOx is carried out
 20 by said NOx treating catalyst:

$$[H_2 / TR]_d > [H_2 / TR]_u \dots (1)$$

$$[H_2 / TR]_d \geq 0.3 \dots (2)$$

where $[H_2 / TR]_u$ is a ratio between a concentration $[H_2]_u$ of
 hydrogen and a concentration $[TR]_u$ of total reducing components in
 20 at least one of exhaust gas in the exhaust gas passageway upstream
 of said hydrogen enriching device and combustion gas in a state
 before undergoing the hydrogen ratio increasing by said hydrogen
 enriching means; and $[H_2 / TR]_d$ is a ratio between a concentration
 $[H_2]_d$ of hydrogen and a concentration $[TR]_d$ of total reducing
 25 components in exhaust gas in the exhaust gas passageway upstream
 of the NOx treating catalyst and downstream of said hydrogen
 enriching device.

30 14. An exhaust gas purifying system as claimed in Claim 13,
 wherein said hydrogen enriching device is arranged to increase a
 ratio of hydrogen to carbon monoxide in the total reducing
 components in exhaust gas so as to meet a relation represented by
 the following formula of $[H_2 / CO]_d > 1$ where $[H_2 / CO]_d$ is a ratio

C) between a concentration [H₂]d of hydrogen and a concentration [CO]d of carbon monoxide in the total reducing components in exhaust gas in the exhaust gas passageway immediately upstream of the NO_x treating catalyst and downstream of said hydrogen enriching device, when reduction of NO_x is carried out by said NO_x treating catalyst.

15. An exhaust gas purifying system as claimed in Claim 5, wherein the CO and HC selective oxidation catalyst has a function of producing hydrogen and contains rhodium and zirconium oxide, the zirconium oxide containing alkaline earth metal and having a composition represented by the following general formula (3):



where X is an alkaline earth metal selected from the group consisting of magnesium, calcium, strontium and barium; a and b are ratios of atoms of elements; and c is a number of oxygen atoms required for satisfying valences of X and Zr, in which a is within a range of from 0.01 to 0.5, b is within a range of from 0.5 to 0.99, and $a + b = 1.0$.

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Sub 16. An exhaust gas purifying system as claimed in Claim 15, wherein the CO and HC selective catalyst further contains palladium and cerium oxide, the palladium being carried in an amount ranging from 20 to 80 % by weight of total palladium on cerium oxide.

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CV 17. An exhaust gas purifying system as claimed in Claim 6, wherein the catalyst containing solid acidic zirconium oxide contains platinum, the solid acidic zirconium oxide containing at least one element selected from the group consisting of titanium, aluminum tungsten, molybdenum and zinc, the solid acidic zirconium oxide having a composition represented by the following general formula (4):

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[Y]_dZr_eO_f... (4)

C17 where Y is at least one element selected from the group consisting of titanium, aluminum, tungsten, molybdenum and zinc; d and e are ratios of atoms of elements; and f is a number of oxygen atoms
5 required for satisfying valences of Y and Zr, in which d is within a range of from 0.01 to 0.5, e is within a range of from 0.5 to 0.99, and d+e = 1.0.

Sub 10 18. An exhaust gas purifying system as claimed in Claim 4, wherein the hydrogen producing catalyst has a function to produce hydrogen from HC and CO in at least one of combustion gas and exhaust gas.

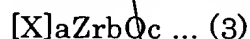
Sub 15 19. An exhaust gas purifying system as claimed in Claim 18, wherein the hydrogen producing catalyst includes a first catalytic component for oxidizing HC and CO to decrease oxygen, said first catalytic component being disposed in a first section of the hydrogen producing catalyst, and a second catalytic component for producing hydrogen and disposed in a second section of the hydrogen producing
20 catalyst, the second section being located downstream of the first section with respect to flow of exhaust gas, so that an amount of oxygen to be contacted with the second catalytic component is decreased.

C25 20. An exhaust gas purifying system as claimed in Claim 19, wherein the first catalytic component includes at least one of palladium and platinum and alumina, at least one of palladium and platinum being contained in an amount ranging from 0.1 to 50 g per
30 one liter of a carrier.

21. An exhaust gas purifying system as claimed in Claim 19, wherein the second catalytic component includes rhodium and zirconium oxide, rhodium being contained in an amount ranging

from 0.1 to 50 g per one liter of a carrier, zirconium oxide being contained in an amount ranging from 10 to 300 g per one liter of the carrier.

- 5 22. An exhaust gas purifying system as claimed in Claim 21, wherein the zirconium oxide contains alkaline earth metal and has a composition represented by the following general formula (3):



10 where X is an alkaline earth metal selected from the group consisting of magnesium, calcium, strontium and barium; a and b are ratios of atoms of elements; and c is a number of oxygen atoms required for satisfying valences of X and Zr, in which a is within a range of from 0.01 to 0.5, b is within a range of from 0.5 to 0.99, and $a + b = 1.0$.

- 15 23. An exhaust gas purifying system as claimed in Claim 18, further comprising a device for controlling exhaust gas a position upstream of the hydrogen producing catalyst to intermittently have a composition in which air-fuel ratio is rich, so as to raise efficiency
20 of production of hydrogen by the hydrogen producing catalyst.

24. An exhaust gas purifying system as claimed in Claim 1, wherein said NO_x treating catalyst contains at least one noble metal selected from the group consisting of platinum, palladium and
25 rhodium, and at least one substance selected from the group consisting of alumina, alkali metal and alkaline earth metal.

25. An exhaust gas purifying system as claimed Claim 1, wherein said NO_x treating catalyst contains at least rhodium and
30 arranged to be capable of reducing NO_x in exhaust gas at a temperature ranging from 260 to 380 °C.

26. An exhaust gas purifying system as claimed in Claim 1,
wherein said combustion device is an internal combustion engine.

27. An exhaust gas purifying system as claimed in Claim 1,
wherein the internal combustion engine is a gasoline-fueled engine
for an automotive vehicle.

28. An exhaust gas purifying system comprising:
a NOx treating catalyst for reducing NOx disposed in an
exhaust gas passageway of a combustion device, to reduce NOx in
presence of reducing components in exhaust gas; and

means for enriching hydrogen disposed upstream of said
NOx treating catalyst with respect to flow of exhaust gas from the
combustion device, said hydrogen enriching means is for increasing
a ratio of hydrogen to total reducing components in at least one of
combustion gas and exhaust gas so as to meet relations represented
by the following formulae (1) and (2), when reduction of NOx is
carried out by said NOx treating catalyst:

$$[H_2 / TR]_d > [H_2 / TR]_u \dots (1)$$

$$[H_2 / TR]_d \geq 0.3 \dots (2)$$

where $[H_2 / TR]_u$ is a ratio between a concentration $[H_2]_u$ of
hydrogen and a concentration $[TR]_u$ of total reducing components in
at least one of exhaust gas in the exhaust gas passageway upstream
of said hydrogen enriching device and combustion gas in a state
before undergoing the hydrogen ratio increasing by said hydrogen
enriching means; and $[H_2 / TR]_d$ is a ratio between a concentration
 $[H_2]_d$ of hydrogen and a concentration $[TR]_d$ of total reducing
components in exhaust gas in the exhaust gas passageway upstream
of the NOx treating catalyst and downstream of said hydrogen
enriching device.

29. A method of purifying exhaust gas from a combustion
device provided with an exhaust gas purifying system including a

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 NOx treating disposed in an exhaust gas passageway of the combustion device, the NOx treating catalyst reducing NOx in presence of reducing components in exhaust gas, said method comprising:

- 5 increasing a ratio of hydrogen to total reducing components in at least one of combustion gas and exhaust gas to be supplied to the NOx treating catalyst so as to meet relations represented by the following formulae (1) and (2), when reduction of NOx is carried out by said NOx treating catalyst:

10 $[H2 / TR]_d > [H2 / TR]_u \dots (1)$

$[H2 / TR]_d \geq 0.3 \dots (2)$

- where $[H2 / TR]_u$ is a ratio between a concentration $[H2]_u$ of hydrogen and a concentration $[TR]_u$ of total reducing components in at least one of exhaust gas in the exhaust gas passageway upstream of said hydrogen enriching device and combustion gas in a state before undergoing the hydrogen ratio increasing; and $[H2 / TR]_d$ is a ratio between a concentration $[H2]_d$ of hydrogen and a concentration $[TR]_d$ of total reducing components in exhaust gas in the exhaust gas passageway upstream of the NOx treating catalyst and in a state after undergoing the hydrogen ratio increasing.
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